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Temporal - Spatial Change of the Vegetation Cover in Ashad and Sitrab Regions - Using Remote Sensing and GIS Techniques- Red Sea State – Sudan

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ABSTRACT

This research analyzes the temporal and spatial change of vegetation cover in Ashad and Sitrab regions in Tokar locality, Red Sea State during 1987-2016 using Remote Sensing and GIS. Three Field surveys were taken place to have primary data about the study area and to have ground points also for helping image interpretation. Landsat 5, 7 and 8 (TM, ETM$^+$ and OLI sensors respectively) satellite images for the years 1987, 1999, 2013 and 2016 were used to interpreted and estimate vegetation cover spatial and temporal change by using NDVI values and unsupervised classification. From the results the vegetation NDVI values ranged in 1987 in the range between (0.0554 -0.1554), (0.337 - 0.2286) in 1999, (0.915 -0.3635) in 2013 and between (0.0470 - 0.2493) in 2016. Field check was used to have specific ground points for area dominated by *Acacia tortilles* and *Prosopis chilensis* by (GPS). Also *Balanites aegyptiaca*, *Capparis decidua* and *Salvadora persica* and other trees were found dispersal. The temporal and spatial differences were noticed from 1987 to 1999 and 2013, where the area decreased from 192.38 to 187.39 and 148.59 Km^2 Respectively. Due to drought and the increasing demand for firewood, pastures and the coal industry. As for the year 2016, the area increased to (175.72) Km^2 due to the increasing in *Prosopis chilensis* trees, especially in Ashad and Sitrab regions. Finally the research developed some recommendations to solve the problem.

Keywords: *NDVI, Ashad, Sitrab, Change detection, GIS, Remote Sensing*

INTRODUCTION

Remote Sensing (RS) and GIS technology is the best tool for researchers from different disciplines (Hoffer, 1978). Singh, (1990) added that remote sensing provides spectral data from satellites without any physical contact with the body digitally, and this digital data is converted into a visual image. Also it is the best reliable source for Earth's surface data in various contexts such as terrain and biodiversity, cultural aspects of land use, etc. Geographic Information System (GIS) is a very modern technology for geographers (James, 1996). Kumari (2009) has indicated that Dangrmond, founder of ESRI Geographic Information Systems, has defined it as a system based on computer applications for collecting, storing, checking, integrating, retrieving, processing, analyzing and displaying spatial data. It includes components such as computer system, software, spatial data, data departments, and analysis procedures for users. NDVI is one of the most successful of many attempts that have simply been made to quickly identify plant areas and their "state", and it is still the most famous and uses the index to detect live plant curtains in multispectral remote sensing data. NDVI not only detects vegetation, but also quantifies the ability to photosynthesize forest parasols. The NDVI value is calculated from the RED and NIR spectral reflectance. The NDVI values vary between -1.0 and +1.0. The low values of NDVI (0.1 and below) correspond to barren areas of rock, sand or snow. The moderate value (0.2-0.3) represents shrub and grassland, while a high value (0.6-0.8) indicates temperate and tropical rainforests (Grward, *et., al*, 1991; John & David, 1999).

Literature on Using Remote Sensing in Vegetation Assessment

Yagoub. *et., al.* (1994) assessed biomass and soil potential in northern Kordofan using the

NDVI indices. They concluded that the land degradation and ecological imbalance in this region was associated with the combined adverse effects of rainfall and mismanagement of land.

Kassas, (1999) used NDVI based on NOAA-AVHRR and rainfall data to monitor drought risk for the Sudan and to produce drought risk map based on NDVI. This study concluded that NDVI-based map enables decision-makers to have a basic overview of areas at risk of drought in the Sudan.

Aziz , (2009) studied the change in the land cover in the period between (1987 - 2007) for selected areas in Karkuk - Iraq in an area of 73700 hectares using remote sensing techniques. Landsat satellite TM images were used for the year 1987 while ETM + was used for the year 2007. Supervised classification was used to identifying land cover using the ER Mapper V6.4 program. It was able to classify common land cover types and temporal changes.

Al-Dulaimi (2013) studied land degradation by analyzing the archive of satellite imagery MODES-NDVI-1KM for the period from 1999 to 2010 to know the changes in the biomass of the vegetation cover during eleven years and ten physiographic units of the research area were separated by analyzing Landsat satellite imagery.

Ibrahim (2016) studied developments in the land cover in Sennar state, using Remote Sensing techniques. Landsat satellite imagery 30 meters spatial resolution for the years 2000, 2005, 2010 were used. Image interpreted and classified using the Erdas program, to several major features and their areas were estimated.

Study Area

The study area is located in Tokar locality to the southeast, 165 km from Port Sudan, between (37 ^{o}.5 - 37 ^{o}.2) longitudes and (18 ^{o}.7 - 18 ^{o}.4) latitudes with an area estimated at 949 km^{2} (Figure 1). Sitrab region is located parallel of the coastal strip. It is bordered to the east by New Tokar, to the west by Jabal Waryaab, to the north by Ashad village, and to the south by the Mays village. This region is inhabited by Arwa, Hadandwa and Rashaida tribes, their population is about 2,100 and 410 family (Planning and International Cooperation Department 2016), 50% of the population practice grazing at a rate of 2-20 heads For each family on average, most of them are unstable and practice agriculture between November and April each year (Pasture and Forage Administration, 2003). The groundwater is found in sediments of Khor Sitrab consisting of gravel and sand with interferences of silt and soft materials that are deposited during the floods. The wells water is sweet and suitable for drinking according to the specifications of the World Health Organization. The groundwater level is between 33-45 meters below the surface of the earth and the Sitrabe zone is considered to be the richest Water regions throughout the year (ACSAD, 2008). Ashad region is also located paralle of the coastal strip, It follows locality of north Tokar, 9 km from the coast and 12 kilometers away from Stirab at Tokar-Port Sudan road, inhabited by Gemilab and Ashraaf tribes. Nuri (2013) reported that the coastal region has rainy winters between November and March, it has a major role in feeding Khor Ashad which is the main source in feeding the wells that people depend on in drinking water. In general, the area suffers from a steep slope, which reduces the deep water percentage inside the soil.

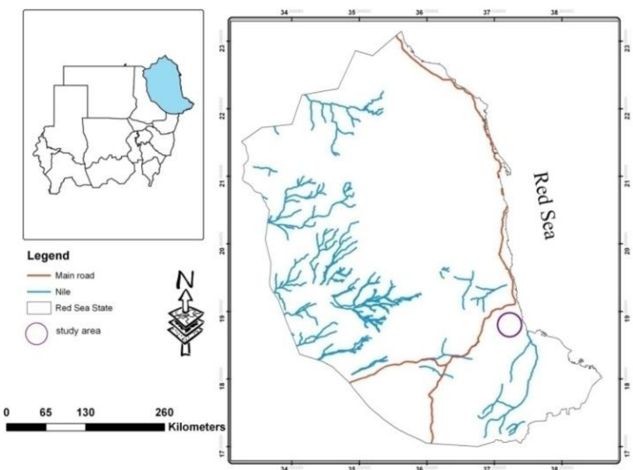

Figure1. *The study area*

METHODOLOGY

The Methods focused on two main axes:

1. Field data and statistical reports (Field Check)
2. Analyzing, processing and interpreting satellite images.

Field Survey

Three field surveys were conducted for data collection for the study area. The first one was in February 2016 for primary survey, and the second visit took place in April 2016 to locate Samar and Mesquite trees areas by using the Global Positioning System GPS. Last one in May 2017 to validate and verify the image interpretation.

Image Acquiring

To achieve the research objectives, several tools were used, including a digital camera, (Garmin 64s) GPS, and Multispectral images created from Landsat TM , ETM$^+$ and OLI (1987, 1999, 2013 and 2016) 30 m spatial resolution, that acquired and downloaded from Earth explorer (USGS), And the Global Land Cover Facility (GLCF) web site. Erdas Imagine 9.2, ENVI 4.7 and Arc/GIS 10.3 software were used for Image Preparation interpretation, analysis and maps lay out. Google Earth was used also for obtaining high spatial resolution data.

Image Preparation and Processing

The images Preparation (layer stacking, radiometric enhancement) have been carried out using ERDAS Imagine 9.2, this depends on the spectral reflection properties of the plants, as the plants absorb the red and green and infrared rays represented by the bands 2,3,4 for Landsat 5 and 7 and the bands 5,4,3 for Landsat (Figure 3) (Kharouf, 1994).

Image Analyzing and Interpreting

Normalized Difference Vegetation Index (NDVI)

The NDVI has values in the range (-1 to +1) where the plant reflects a high percentage of the near infrared spectrum and a lower percentage of the green spectrum, and the vegetation appears clearly in white. Positive values indicates to green vegetation, and the greater positive value, indicates to the intensity of greening and an increase in the reflection of the near red spectrum (Kriegler *et al.*, 1969; Prince *et al.*, 1995).

NDVI = (NIR – RED) / (NIR+RED)

NIR = Near Infrared

RED = Red

Spatial Temporal Change Using the NDVI in the Area

It is the use of a multi-time data set to distinguish the areas whose land cover changes between different dates (Singh, 1990). Gibbard *et., al*, (2005) explained that the temporal changes of space data is one of the most important applications that are used to study the quantitative and qualitative changes of a region. Also Vikram and Bhamare (2012) added that it is considered an important application for vegetation studies and land uses.

The Normalized Difference Vegetation Indices (NDVI) of Landsat images dated (1987 and 1999), (1999 and 2013), (2013 and 2016), were subtracted from each other to produce NDVI change images using Arc/Info 10.3 software.

RESULTS AND DISCUSSION

Vegetation Survey

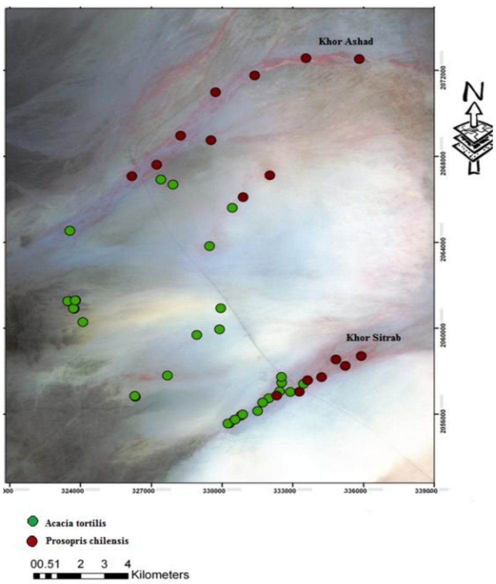

Figure2. *Represent area dominated by Acacia tortilles and Prosopis chilensis*

The region was visited to interpret the satellite images and to identify and take ground points of the areas covered by *Acacia tortilles* and *Prosopis chilensis*. Figure (2), shows ground points for the areas which dominated by *Acacia tortilles* especially in the area between Ashad and Stirab and *Prosopis chilensis* especially in the areas of lagoons. From Table (1), which presents tree species found in the study area, we noticed that there were *Prosopis chilensis and Acacia tortillis* in addition to that *Avicennia marina, Sueda monica, were found beyond the red sea coast and* scattered tree species contain *Balanites aegyptica, Capparis decidua, Calotropis procera, Salvadora Porsica* were detected between the sea coast and the mountain plains.

Table1. *Tree species in the study area*

Family	Local Name	Scientific Name	No
Acanthaceae	Mangrove	*Avicennia marina*	1
Amaranthaceae	Adaleeb	*Sueda monica*	2
Leguminosae	Sammor	*Acacia tortillis*	3
Balanitaceae	Higleege	*Balanites aegyptiaca*	4
Capparaceae	Tondob	*Capparis deciduas*	5
Apocynaceae	Osher	*Calotropis procera*	6
Leguminosae	Mesquite	*Prosopis chilensis*	7
Salvadoraceae	Arack	*Salvadora Persica*	8
Apocynaceae	Markh	*Leptadinia Pyrotechnica*	9

Image Interpretation and Analysis

Land sat images were prepared by stacking, subset the study area and enhancement. (Figure 3)

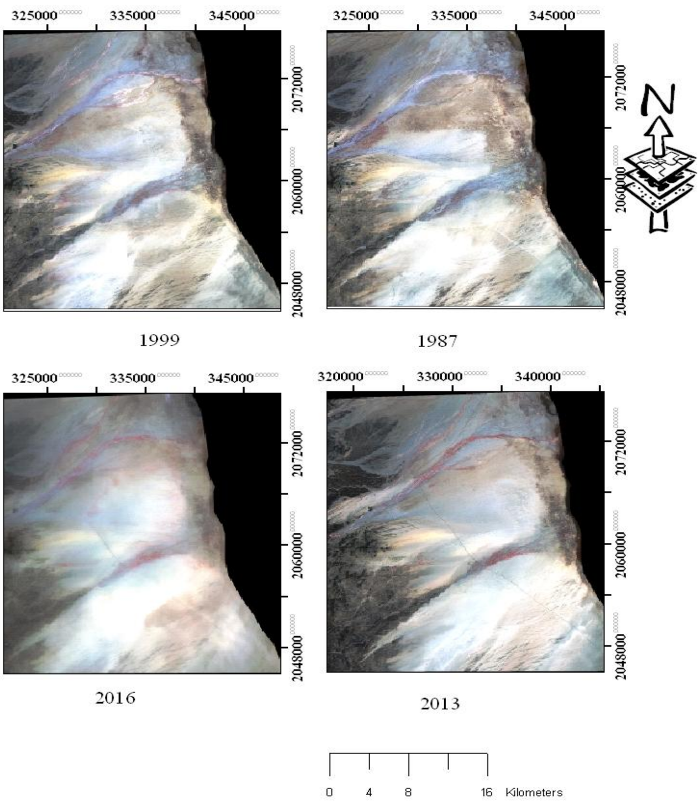

Figure3. *Radiometric enhancement of Land sat satellite images for the years (1987, 1999, 2013, and 2016)*

Analysis of NDVI Images:

Figure (4) shows images interpreted using NDVI index. From the figure it was found that the values of NDVI levels for the year 1987 ranged between (-0.144578 to 0.282759), (-0.107914 to 0.516279) in the year 1999 and (-0.107492 to 0.586498) in 2013 while in the year 2016 it ranged between (0.0934256 to 0.361111). The difference in the values of the NDVI between the different years is due to the difference of chlorophyll content of the vegetation cover leaves. These referred to the scarce and dispersal amount of in the annual rainfall in the study years. Plants that contain large amounts of chlorophyll absorbs blue and red wave length and reflect green and infrared, as the intensity of white increases in NDVI values, indicating a healthy vegetation cover with a high percentage of chlorophyll (Goward *et al*, 1991).

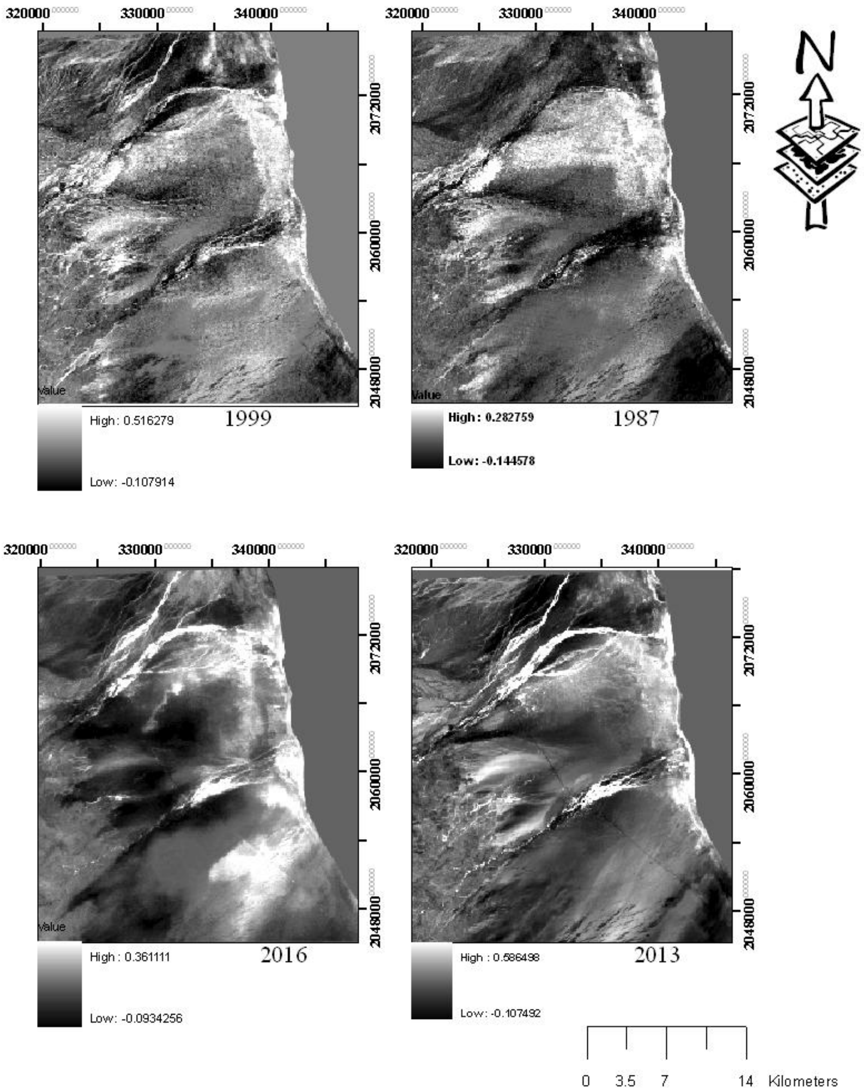

Figure4. *NDVI images from Land sat (MSS, TM, ETM+ and OLI) for the years (1987-1999-2013-2016) respectively*

Images interpretation

The temporal changes in the vegetation cover were estimated from 1987 to 1999, 1999 to 2013 and 2013 to 2016. Figure (5) shows the temporal changes for the three periods. From the figure the brown color (the highest grades of color) indicates the positive change (an increase in the vegetation cover), while both the white and pink color (the lowest grades in color) indicated the negative change, (decrease in the vegetation cover), either the rest of the colors (which represent the mid tones) indicate that there is no change in the reflection so in the vegetation cover. From the figure in period from (1987-1999) there was an increase in the vegetation in the area south of Ashad and the coastal area as well as some small areas at the beginning and south of the Khor Sitrab on the direction of the mountain chain, which was dominated by Acacia trees at that period according to (Abd elrahman and Knut, 2007).

Vegetation cover degraded in parts of areas north and south and inside Khor Sitrab and north of Ashad. In the period (1999-2013), the vegetation decreased in both Khor Ashad and Sitrab and the area between them in addition to the area north of Ashad and the south of Sitrab villages. Generally increasing in vegetation was very rare in this period and the cover was sparse.

In the period (2013-2016) the vegetation cover increase in the course of the valleys, and a few areas between Khor Ashad and Sitrab, the coastal area and south of Sitrab. Through observation from the field survey, most of the increasing inside the valleys was Mesquite trees. Also we can notice that the vegetation degraded between Ashad and Sitrab.

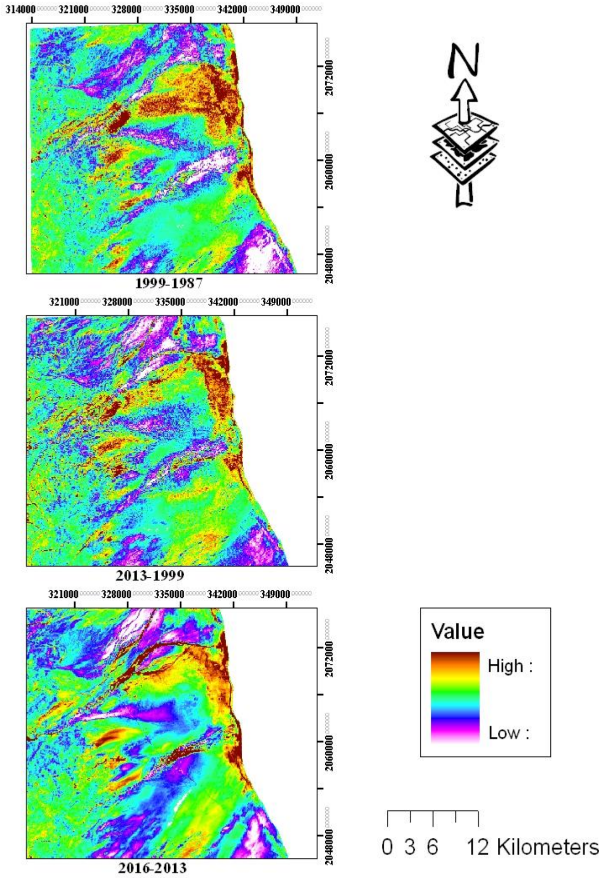

Figure5. *Chang Detection of vegetation cover in the study area for the period from (1987 - 1999 - 1999 - 2013 - 2016)*

Vegetation Cover area Assessment:

Using the ENVI 4.7 software and NDVI images, the unsupervised classification –isodata was performed. By comparing the classified images and composite enhancement images, it was possible to identify the classes that represent the vegetation of the NDVI layers. Post Classification was used to merge vegetation classes to one class, which ranged from (0.0554-0.1554) in 1987, (0.337 - 0.2286) in 1999, between (0.0915- 0.3635) in 2013 and in 2016 ranged (0.0470 - 0.2493). This decrease and increase of NDVI values corresponds to that the vegetation index is affected by the greenness or drought of plants; especially if the vegetation is a mixture of green and dry plants (Tucker, 1979), he also mentioned that it was important to use the field work to interpret the satellite images to know the species in the study area.

Using the ENVI 4.7 program the vegetation class was converted to vector layer and then to shape files (shp), in order to estimate the area of the vegetation cover using Arcgis10.3 program. Table (2), shows the areas covered by vegetation /km^2, in Ashad and Sitrab for the years (1987 - 1999 - 2013 - 2016). And Figure. 6, shows the areas covered by vegetation.

Table2. *Vegetation cover area /Km^2 from 1987 to 2016*

Year	Area of vegetation / Km^2
1987	192.38
1999	187.39
2013	148.59
2016	175.72

From Table (2), there was deterioration in the vegetation cover between 1987 to 1999, it was decreased from 192.38 Km^2 in 1987 to 187.39 Km^2 in 1999. This agree with Nuri (2013) who mentioned that the drought period affected Red Sea state and led to deterioration of natural resources especially the vegetation. The vegetation cover area decreased in 2013 to 148.39 Km^2, (Nuri, 2013) explained that civil constructions such as roads (Suakin- Tokar high way road) decline of the alluvium sediment deposition at the khor mouth so it was one of the main reason of deterioration. In addition to that, drilling underground wells in the period between the year (1999-2013), especially in the region of Sitrab, led to an increase in water resources throughout the year, which contributed to stability for the nomadic shepherds, this resulted in pressure on the vegetation cover as pasture throughout the year as well as the daily use of firewood. Also expansion of the coal industry from *Acacia* and *Prosopis* trees. (Ali and Mohamed, 1991) added that the excessive use of (*Acacia tortilles*) and (*Avicennia marina*) wood as fuel for municipal ovens in the city of Suakin led to the deterioration of these species. Abd Elrahman and Knut (2007) explained that the removal of vegetation and the transformation of some areas into agricultural land led to the cracking, fragmentation and soil erosion.

The area covered by the plant increased to 175.72 Km^2 in the year 2016. The report of the National Authority for Forests in the Red Sea (2016) revealed that in recent years, the rates of rain increased and resulted in natural germination of the trees of Samar (*Acacia tortilles*) and (*Prosopis chilensis*), also encouraged scattering seeds of trees that are resistant to the region's environment in addition to raising environmental awareness and using energy alternatives such as improved stoves reduced pressure on the living mass and increased the prevalence of (*Prosopis chilensis*), especially within the Ashad and Sitrab valleys (Saleh, 2015). Despite the increasing in the area covered with vegetation, there is a deterioration in the plant composition of the (*Sueda monica*) and(*Salvadora Porsica*) as a result of unguided exploitation and unjust cutting, early grazing, especially in Ashad, where residents practice grazing around the valley for most of the year (Idris, 2013), With the lack of protection from the competent authorities and the local community for germination initiatives during the germination period, which leads to their elimination. All of this led to sand creeping, soil erosion and degradation, in addition to the wrong practices of the human being that led to increasing pressure on the environment and disturbing the balance as shepherds resorted to cutting the trees of Samar and selling them, And finding alternatives to per capita income by selling charcoal and firewood (Saleh, 2015) , in addition to that there is an absence or un active of legislation and laws.

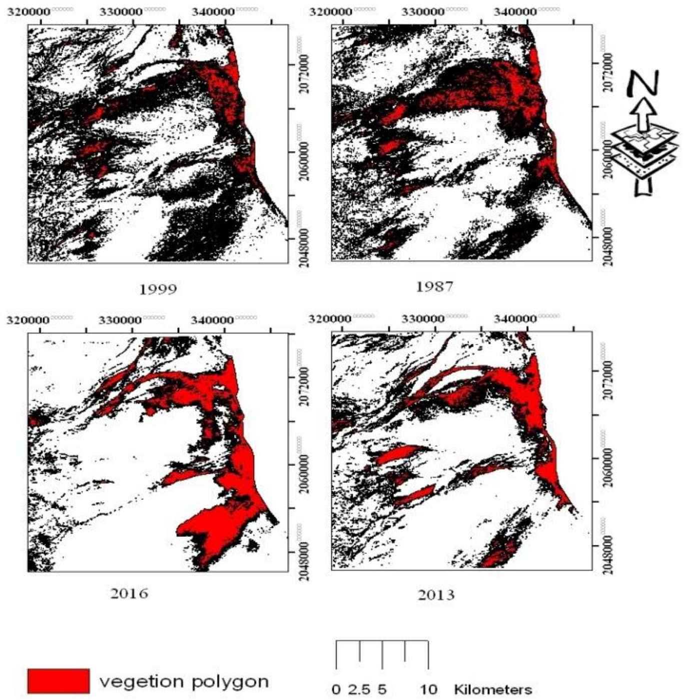

Figure6. *Vegetation cover area from Landsat images for the years (1987-1999-2013-2016)*

Conclusion

Based on the results of this study, we found that there were qualitative and quantitative composition changes of the vegetation in Ashad and Sitrab regions from 1987 to 2016. *Acacia tortilles* and *Prosopis chilensis* spieces were the dominant species in the area in addition of (*Avicennia marina*) and (*Sueda monica)*, in the coastal plain. There were other sparce speciese represented in (*Zaygophyllum album*), (*Balanites aegyptiaca*), (*Capparis decidua*), (*Calotropis procera*) and (*Panicum turgidum*). Deterioration and decreasing of vegetation cover during the period (1987- 1999 to 2013) was a result of grazing, logging and civil constructions. In 2016, the area covered by vegetation increased to 175.72 Km^2 as a result of the increasing in (*Prosopis chilensis*), which contributed preserving soil in addition to its economic importance to the local community, as it is used in the manufacture of coal, which has become one of the most important sources of income in the region.

Recommendations

Raising the environmental awareness of the residents of the local community through various media outlets of the dangers of wrong practices, such as overgrazing, logging and random logging, and adopting the principle of sustainable environmental development and its application when developing development plans for future projects.

To compel the local authorities and the relevant authorities to monitor the implementation and implementation of laws and legislations.

Building and establishing a comprehensive database for land uses by adopting remote sensing and GIS technologies to benefit from them in setting comprehensive development plans in the region and developing degraded areas from them.

Intensifying forest plantation programs and using water harvesting technologies in Ashad and Sitrab. also limiting the spread of Mesquite, especially in valleys, and replace them with trees of economic value , which has the ability to withstand climatic conditions in the region, reduce manifestations of desertification, and stop the movement of sand dunes

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